

The Chase to Capture Gamma Ray Bursts

Gamma-ray bursts are the most powerful explosions in the universe, thought to be the birth cries of black holes. It has taken 40 years of international cooperation and competition to begin to unravel the mystery of their origin. The most recent chapter in this field is being written by the SWIFT mission, a fast-response satellite with 3 power telescopes. An international team from countries all over the world participates in the chase to capture the fading light of bursts detected by SWIFT. This talk will discuss the challenges and excitement of building this space observatory. New results will be presented on our growing understanding of exploding stars and fiery mergers of orbiting stars.

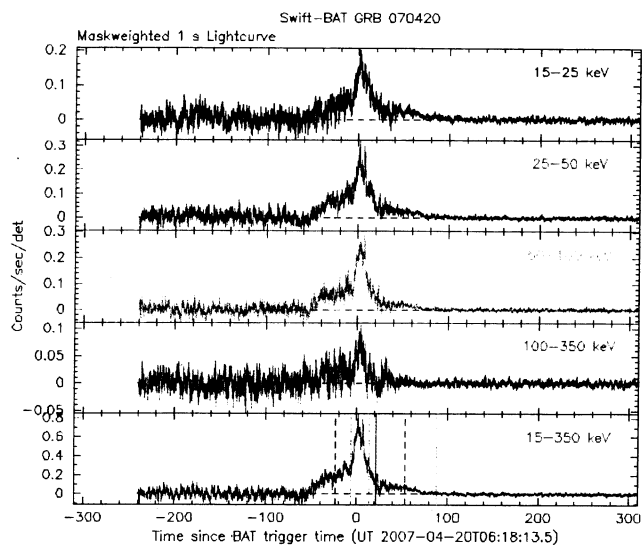
GRB Discoveries with Swift

Neil Gehrels

NASA-GSFC

Swift GRB 070420

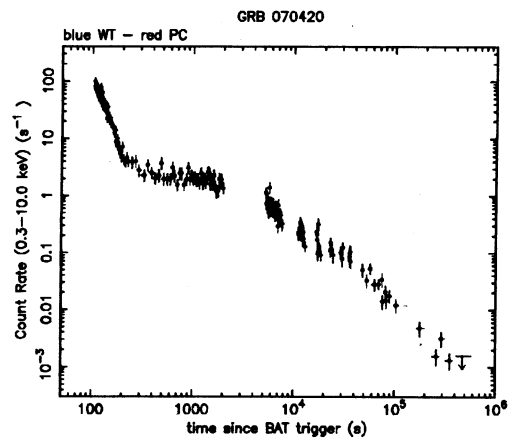
BAT prompt emission



3 instruments, each with:

- lightcurves
- images
- spectra

XRT afterglow



Long GRBs

63 *Swift* Long GRB Redshifts

6.29	050904
5.47	060927
5.3	050814
5.11	060522
4.9	060510B
4.41	060223A
4.27	050505
4.05	060206
3.97	050730
3.91	060210
3.71	060605
3.69	060906
3.62	070721B
3.53	060115
3.44	061110B
3.43	060707
3.36	061222B
3.34	050908
3.24	050319
3.21	060926
3.21	060526
3.08	060607A
2.95	070411
2.90	050401
2.82	050603
2.71	060714
2.68	060604
2.61	050820A
2.50	070529
2.45	070802
2.43	060908
2.35	051109A

2.35	070110
2.31	070506
2.30	060124
2.20	050922C
2.17	070810
2.04	070611
1.95	050315
1.71	050802
1.55	051111
1.51	060502A
1.50	070306
1.49	060418
1.44	050318
1.31	061121
1.29	050126
1.26	061007
1.17	070208
0.97	070419A
0.94	051016B
0.84	070318
0.83	050824
0.76	061110A
0.70	060904B
0.65	050416A
0.62	070612A
0.61	050525A
0.54	060729
0.44	060512
0.125	060614
0.089	060505
0.033	060218

<i>z</i>	GRB	Optical/IR Brightness
6.29	050904	J = 18 @ 3 hrs
5.6	060927	I = 16 @ 2 min
5.3	050814	K = 18 @ 23 hrs
5.11	060522	R = 21 @ 1.5 hrs

GRB Host Spectroscopy

GRB 050505

$z = 4.275$

Damped Ly α

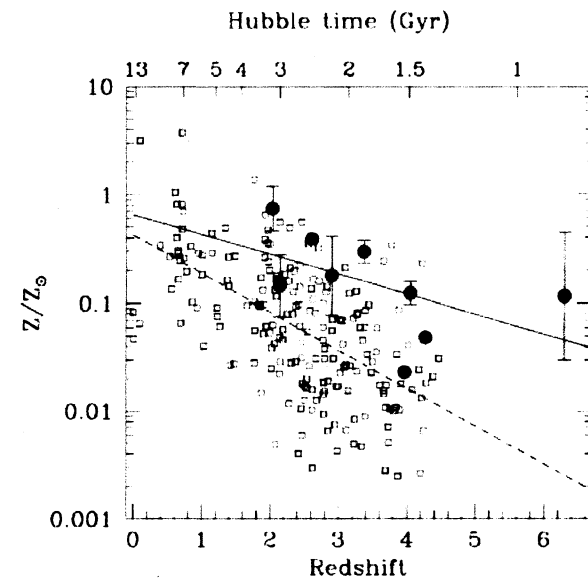
$N(\text{HI}) = 10^{22} \text{ cm}^{-2}$

$n \sim 10^2 \text{ cm}^{-3}$

$Z = 0.06 Z_{\odot}$

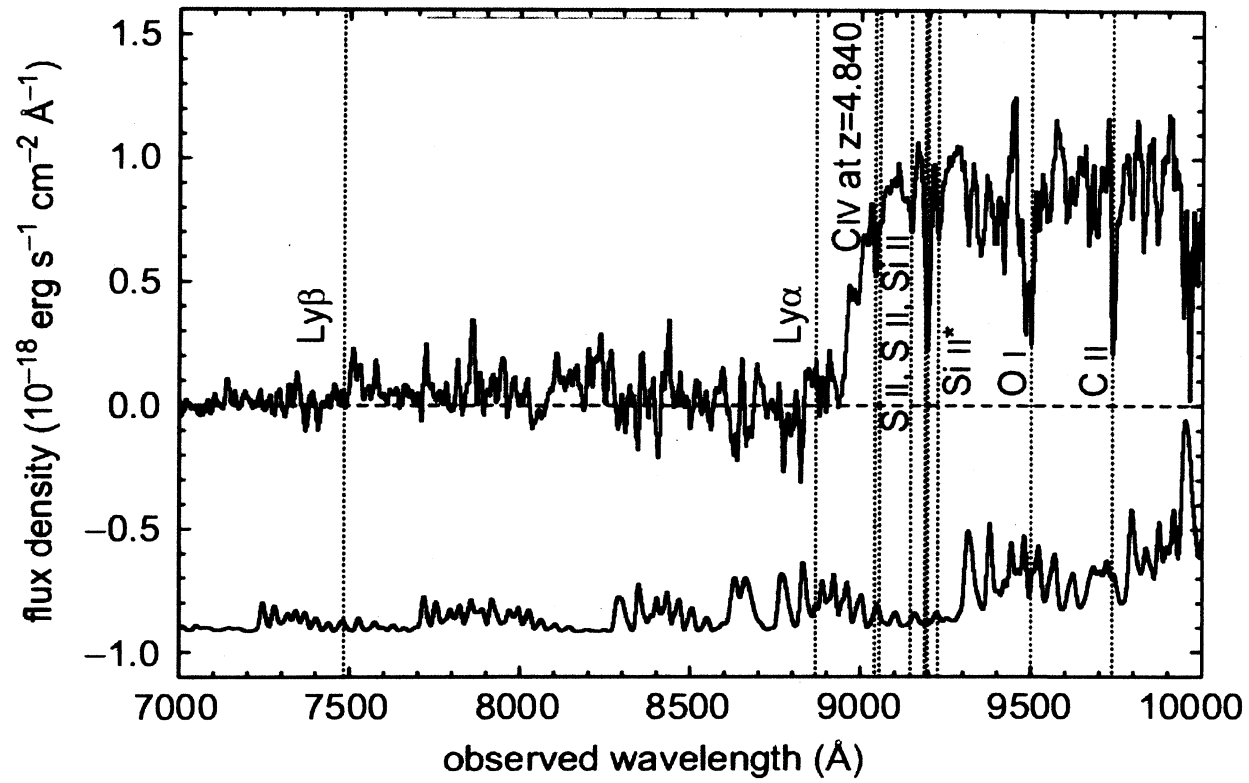
$M_{\text{progenitor}} < 25 M_{\odot}$

Metallicity vs Redshift



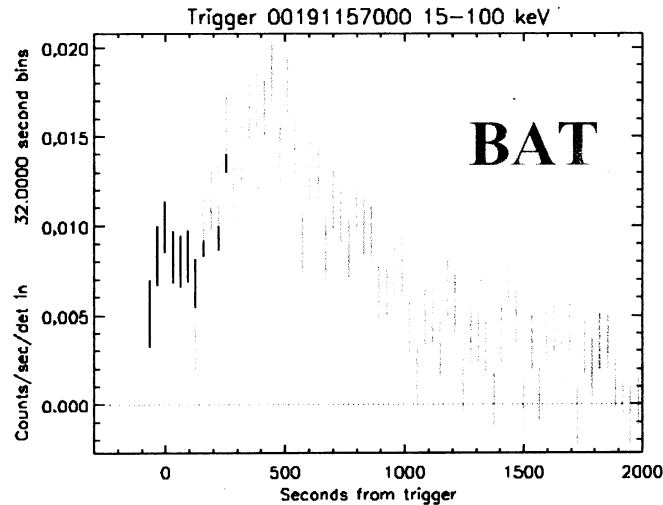
Savaglio 2006

GRB 050904 $z=6.29$



Subaru Telescope
Kowai et al. 2006

GRB 060218: GRB + Supernova



Super-long GRB - ~35 minutes

BAT, XRT, UVOT during GRB

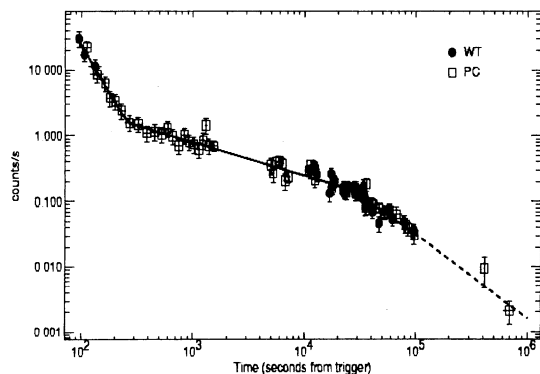
$z = 0.033$ $d = 145$ Mpc

SN 2006aj SN Ib/c

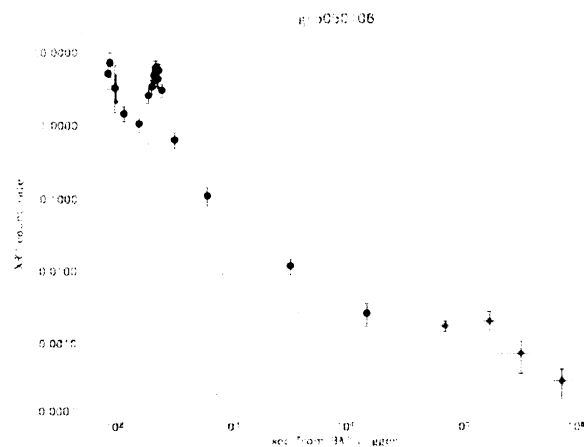
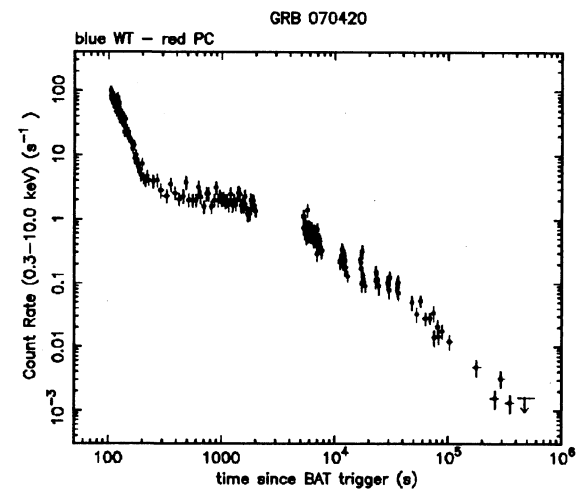
$E_{\text{iso}} = \text{few} \times 10^{49} \text{ erg}$ - underluminous

Afterglows

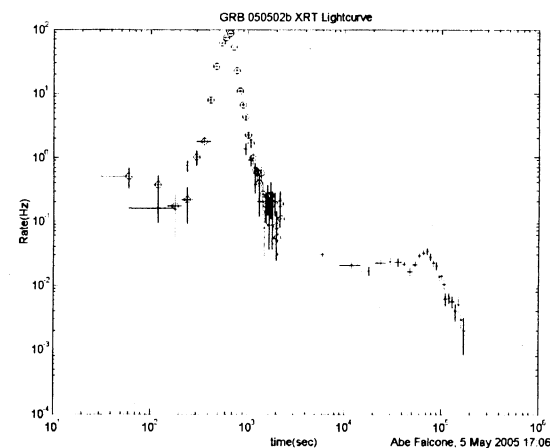
Typical *Swift* X-ray Lightcurves



**50% with
bright early
component**

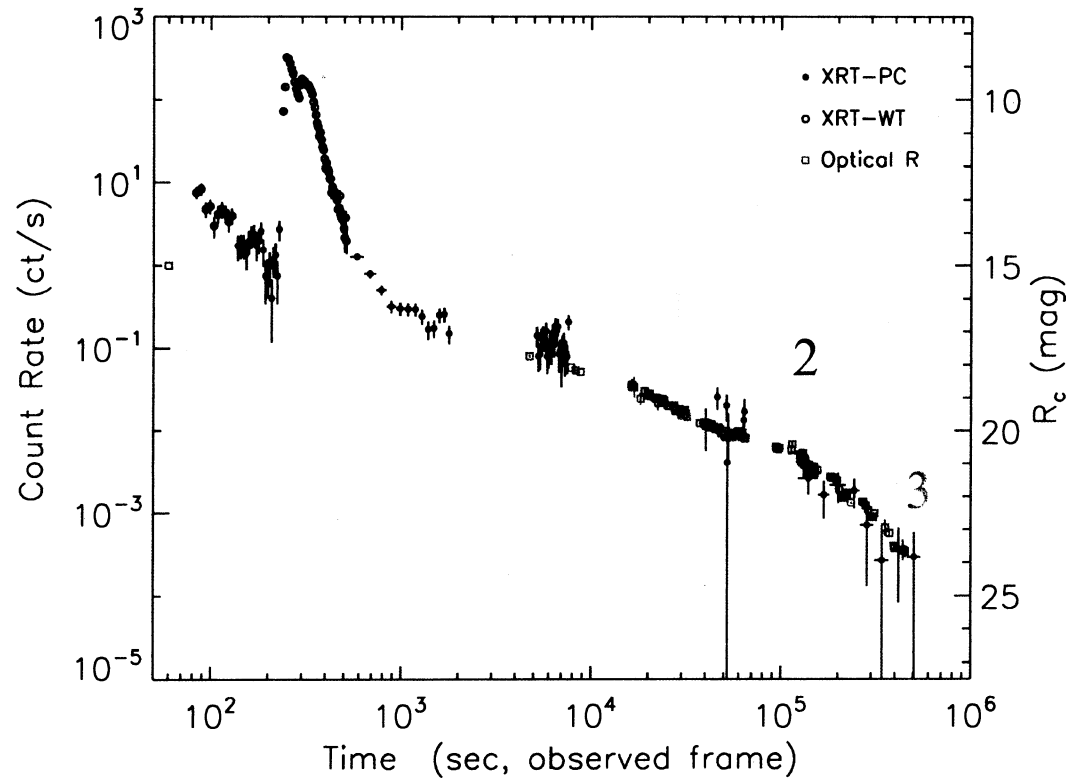


**>30% with
flares**



Burrows et al. 2005

Achromatic Jet Break - GRB 060526



$z=3.21$
jet angle = 7°

Dai et al. 2007

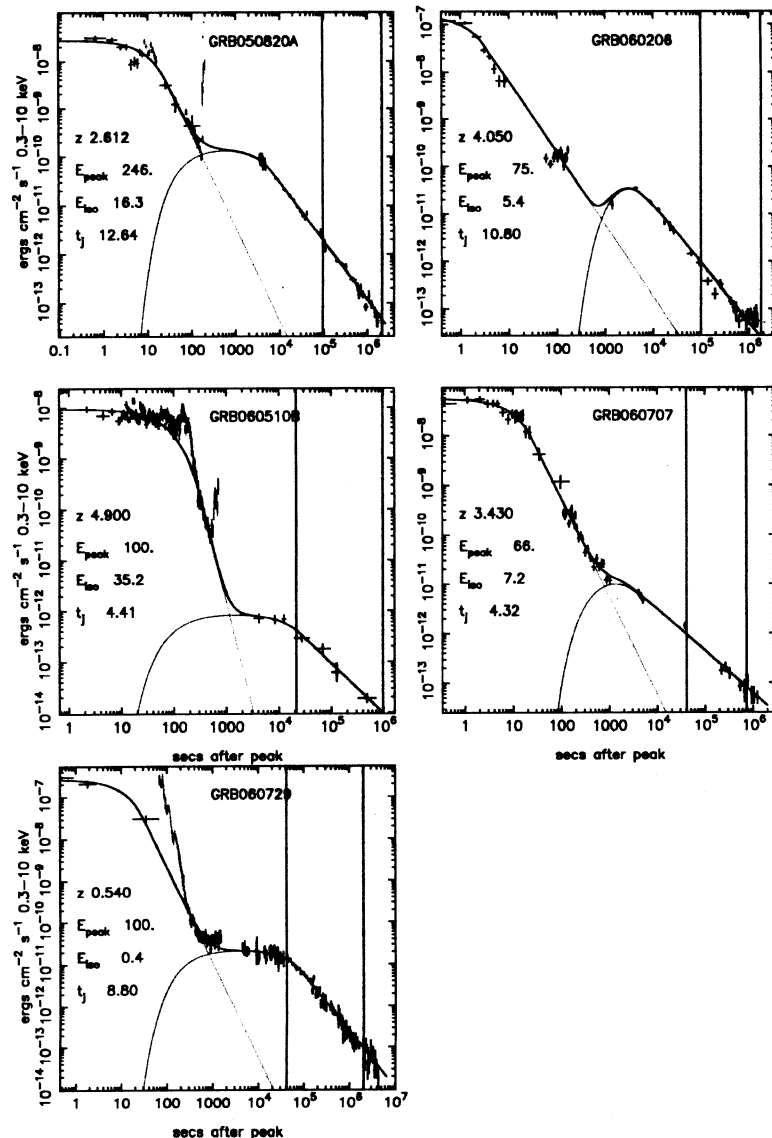
Puzzling Data

- Many GRBs do not show jet breaks
- In other cases, optical and X-ray breaks are not coincident.
- Complex shape of afterglow lightcurves makes jet breaks hard to find

Other new papers:

Curran et al. (astro-ph 0706.1188) - evidence for achromatic breaks in several Swift GRBs

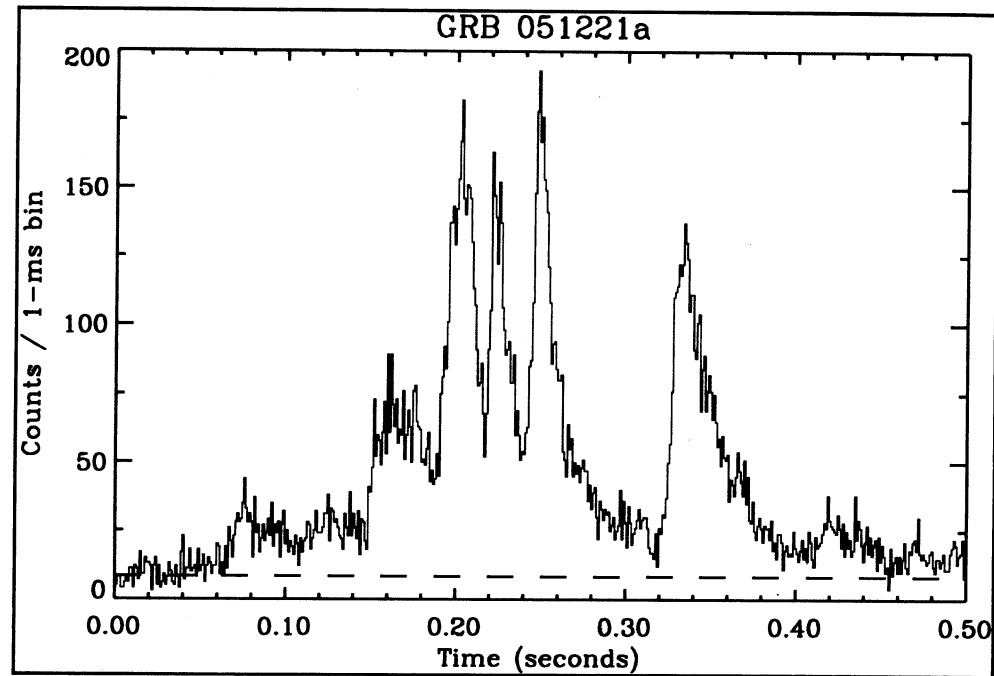
Oates et al. (astro-ph 0706.0669) - GRB 050802 case with X-ray break clearly seen but no optical break



Willingale et al. 2007

Short GRBs

Short GRB Time Structure



Short GRB - Current Status

Swift short GRB observations

- 23 short bursts detected (+ 2 from HETE, +1 from INTEGRAL)
- 78% with X-ray afterglow detected by XRT (95% long GRBs)
- 28% with optical detection (58% long GRBs)
- ~50% with host IDs

~1/2 shorts accompanied by soft
extended emission up to 100 sec

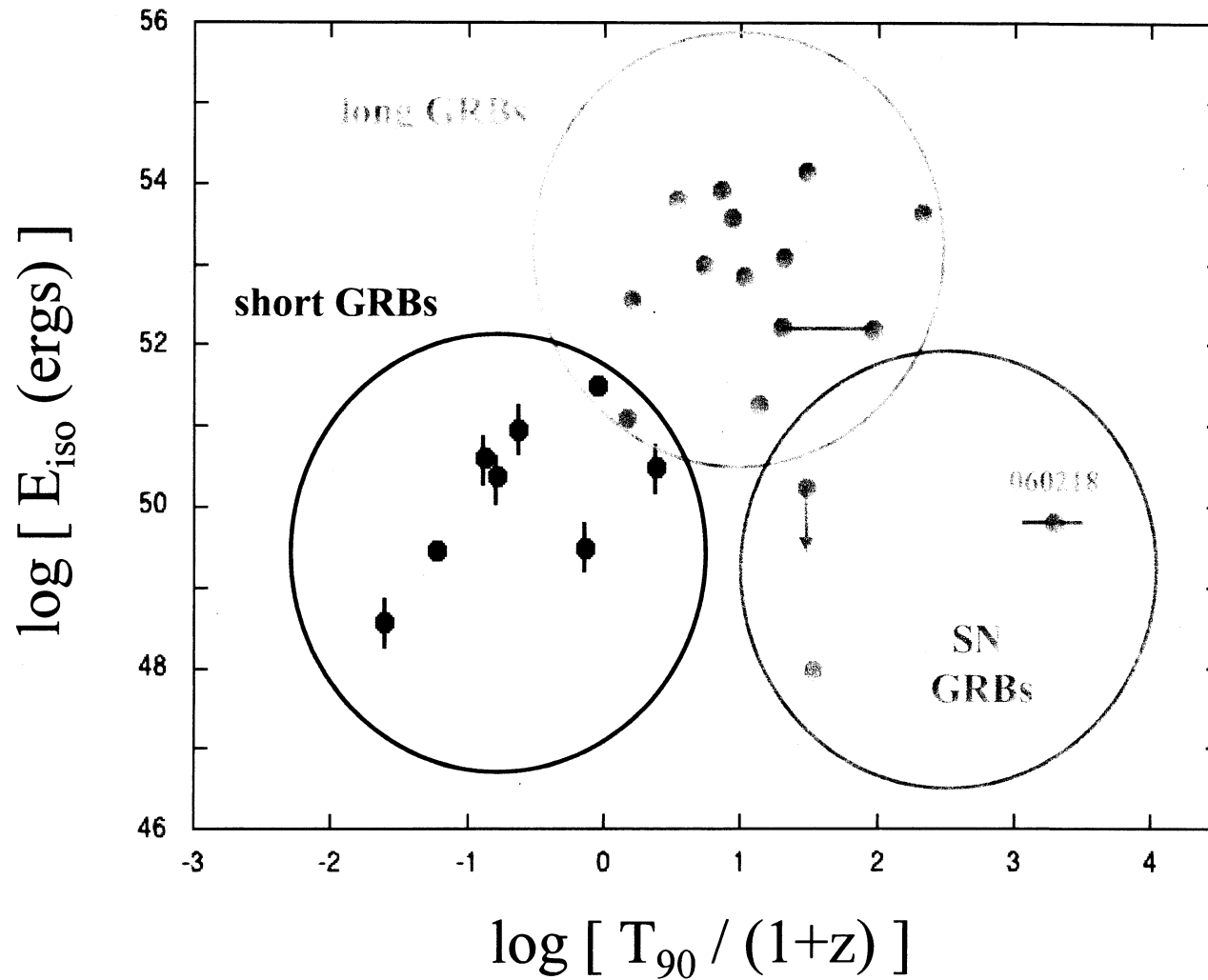
Redshift range from $z = 0.2$ to 1

- $\langle z \rangle_{\text{short}} = 0.6$
- $\langle z \rangle_{\text{long}} = 2.3$

GRB 070714B $z = 0.92$
(Graham et al. 2007)

3 Types of GRBs

Swift GRBs (mostly)



Implications for Grav. Wave Detections

Assuming all short GRBs are due to NS-NS mergers, merger rate is $\sim 300 \text{ Gpc}^{-3} \text{ yr}^{-1}$

[Consistent with NS-NS population synthesis modeling O'Shaughnessy, Kalogera, & Belczynski (2005)]

\Rightarrow Advanced LIGO detection rate of $\sim 30 \text{ yr}^{-1}$

Nakar et al.:

Possible much higher rates of $10^5 \text{ Gpc}^{-3} \text{ yr}^{-1}$.

\Rightarrow Detection with enhance LIGO

Swift will be in orbit until > 2020

